1.0 Introduction

This section provides background information about the Superfund Innovative Technology Evaluation (SITE) Program and reports related to it; describes Envirobond™; presents the objectives of the SITE demonstration; and provides information about key contacts.

1.1 Description of SITE Program and Reports

This section provides information about the purpose, history, goals, and implementation of the SITE program, and about reports that document the results of SITE demonstrations.

1.1.1 Purpose, History, Goals, and Implementation of the SITE Program

The primary purpose of the SITE program is to advance the development and demonstration, and thereby establish the commercial availability, of innovative treatment technologies applicable to Superfund and other hazardous waste sites. The SITE program was established by the U.S. Environmental Protection Agency's (EPA) Office of Solid Waste and Emergency Response (OSWER) and Office of Research and Development (ORD) in response to the Superfund Amendments and Reauthorization Act of 1986 (SARA), which recognizes the need for an alternative or innovative treatment technology research and demonstration program. The SITE program is administered by ORD's National Risk Management Research Laboratory (NRMRL) in Cincinnati, Ohio. The overall goal of the SITE program is to carry out a program of research, evaluation, testing, development, and demonstration of alternative or innovative treatment technologies that can be used in response actions to achieve more permanent protection of human health and the environment.

Each SITE demonstration evaluates the performance of a technology in treating a specific waste. The waste characteristics at other sites may differ from the characteristics of those treated during the SITE demonstration. Further, the successful field demonstration of a technology at one site does not necessarily ensure that it will be applicable at other sites. Finally, data from the field demonstration may require extrapolation to estimate (1) the operating ranges under which the technology will perform satisfactorily and (2) the costs associated with application of the technology. Therefore, only limited conclusions can be drawn from a single field demonstration, such as a SITE technology demonstration.

The SITE program consists of four components: (1) the Demonstration Program, (2) the Emerging Technology Program, (3) the Monitoring and Measurement Technologies Program, and (4) the Technology Transfer Program. The SITE demonstration described in this innovative technology evaluation report (ITER) was conducted under the Demonstration Program. The objective of the Demonstration Program is to provide reliable performance and cost data on innovative technologies so that potential users can assess a given technology's suitability for cleanup of a specific site. To produce useful and reliable data, demonstrations are conducted at hazardous waste sites or under conditions that closely simulate actual conditions at waste sites. The program's rigorous quality assurance and quality control (QA/QC) procedures provide for objective and carefully controlled testing of field-ready technologies. Innovative technologies chosen for a SITE demonstration must be pilot- or full-scale applications and must offer some advantage over existing technologies.

Implementation of the SITE program is a significant, ongoing effort that involves OSWER, ORD, various EPA regions, and private business concerns, including technology developers and parties responsible for site remediation. Cooperative agreements between EPA and the innovative technology developer establish responsibilities for conducting the demonstrations and evaluating the technology. The developer typically is responsible for demonstrating the technology at the selected site and is expected to pay any costs of transportation, operation, and removal of related equipment. EPA typically is responsible for project planning, site preparation, provision of technical assistance, sampling and analysis, QA/QC, preparation of reports, dissemination of information, and transportation and disposal of treated waste materials.

1.1.2 Documentation of the Results of SITE Demonstrations

The results of each SITE demonstration are reported in an ITER and a technology evaluation report (TER). The ITER is intended for use by EPA remedial project managers (RPM) and on-scene coordinators, contractors, and others involved in the remediation decision-making process and in the implementation of specific remedial actions. The ITER is designed to aid decision makers in determining whether specific technologies warrant further consideration as options applicable to particular cleanup operations. To encourage the general use of demonstrated technologies, EPA provides information about the applicability of each technology to specific sites and wastes. The

ITER provides information about costs and site-specific characteristics. It also discusses the advantages, disadvantages, and limitations of the technology.

The purpose of the TER is to consolidate all information and records acquired during the demonstration. The TER presents both a narrative and tables and graphs that summarize data. The narrative discusses predemonstration, demonstration, and postdemonstration activities, as well as any deviations from the quality assurance project plan (QAPP) for the demonstration during those activities and the effects of such deviations. The data tables summarize the QA/QC data. EPA does not publish the TER; instead, a copy is retained as a reference by the EPA project manager for use in responding to public inquiries and for recordkeeping purposes.

1.2 Description of Envirobond™

The Envirobond™ process is a combination of a proprietary powder and solution that binds with metals in contaminated soils and other wastes. Rocky Mountain Remediation Services, L.L.C. (RMRS), the developer of the process, claims that the Envirobond™ process effectively prevents metals from leaching and can be used with mechanical compaction to reduce the overall volume of contaminated media by 30 to 50 percent. The Envirobond™ process generates no secondary wastes and involves minimal handling, transportation, and disposal costs.

The Envirobond™ process consists of a mixture of additives containing oxygen, nitrogen, and phosphorous; each additive has an affinity for a specific class of metals. RMRS claims that the Envirobond™ process converts each metal contaminant from its leachable form to an insoluble, stable, nonhazardous metallic complex. The Envirobond™ process is essentially a mixture of ligands that act as chelating agents. In the chelation reaction, coordinate bonds attach the metal ion to at least two ligand nonmetal ions to form a heterocyclic ring. The resulting ring structure is inherently more stable than simpler structures formed in many binding processes. RMRS claims that, by effectively binding the metals, the Envirobond™ process reduces the waste stream's leachable metal concentrations to less than regulated levels, and thereby reduces the risks posed to human health and the environment.

The Envirobond™ process can be deployed as an *in situ* or *ex situ* treatment process. RMRS reports that the Envirobond™ process is capable of achieving processing rates of 20 to 40 tons per hour for *ex situ* treatment and can be used with contaminated media containing as much as 10 percent debris.

1.3 Overview and Objectives of the SITE Demonstration

This section provides information about (1) the site background and location, (2) the objectives of the SITE demonstration, (3) demonstration activities, and (4) long-term monitoring activities.

1.3.1 Site Background

The villages of Crooksville and Roseville, located along the Muskingum and Perry County line in eastern Ohio, are famous for a long history of pottery production. During the 100-year period of pottery manufacturing in those villages, broken and defective (off-specification [off-spec]) pottery was disposed of in several areas. Disposal practices were not monitored or documented clearly. Sampling conducted in the region by the Ohio Environmental Protection Agency (OEPA) in 1997 identified 14 former potteries and pottery disposal sites at which significant lead contamination was present. Results of analysis of the soil samples collected by OEPA in 1997 indicated elevated levels of lead in shallow soils throughout the area (OEPA 1998) identified as the Crooksville/Roseville Pottery Area of Concern (CRPAC). Much of the lead contamination is associated with the disposal of unused glazing materials or of off-spec pottery that was not fired in a kiln.

In 1996, OEPA entered into a cooperative agreement with EPA to conduct an investigation of the CRPAC under a regional geographic initiative (GI). The GI program provides grants for projects that an EPA region, a state, or a locality has identified as high priority and at which the potential for risk reduction is significant. The GI program allows EPA regions to address unique, multimedia regional environmental problems that may pose risks to human health or to the environment, such as the widespread lead contamination found at the CRPAC.

The purpose of the GI of the investigation of the CRPAC was to determine whether the long history of pottery operations there, from the late 1800s through the 1960s, caused any increases over background levels of concentrations of heavy metals in soil, groundwater, surface water, or air. The results of analysis of soil and groundwater samples collected in 1997 indicate elevated levels of lead are present in shallow soils and groundwater throughout the CRPAC (OEPA 1998).

1.3.2 Site Location

OEPA selected four potential demonstration sites in the CRPAC on the basis of the analytical results for samples collected as part of the GI. Before the demonstration was conducted, SITE personnel collected and analyzed soil samples from the potential demonstration sites to determine the extent of the lead contamination at those sites.

On the basis of the analytical results and discussions with representatives of OEPA, two sites in the CRPAC were selected for the SITE demonstration project. One site is a former trailer park in Roseville, Ohio, which is one of many residential areas in the CRPAC that have been affected by the disposal of the pottery waste. The other site, also in Roseville, Ohio, is located in an industrial area, adjacent to an inactive pottery factory. Figure 1-1 shows the locations of the demonstration sites.

1.3.3 SITE Demonstration Objectives

OEPA applied to the SITE program for assistance in evaluating innovative, cost-effective technologies that could be

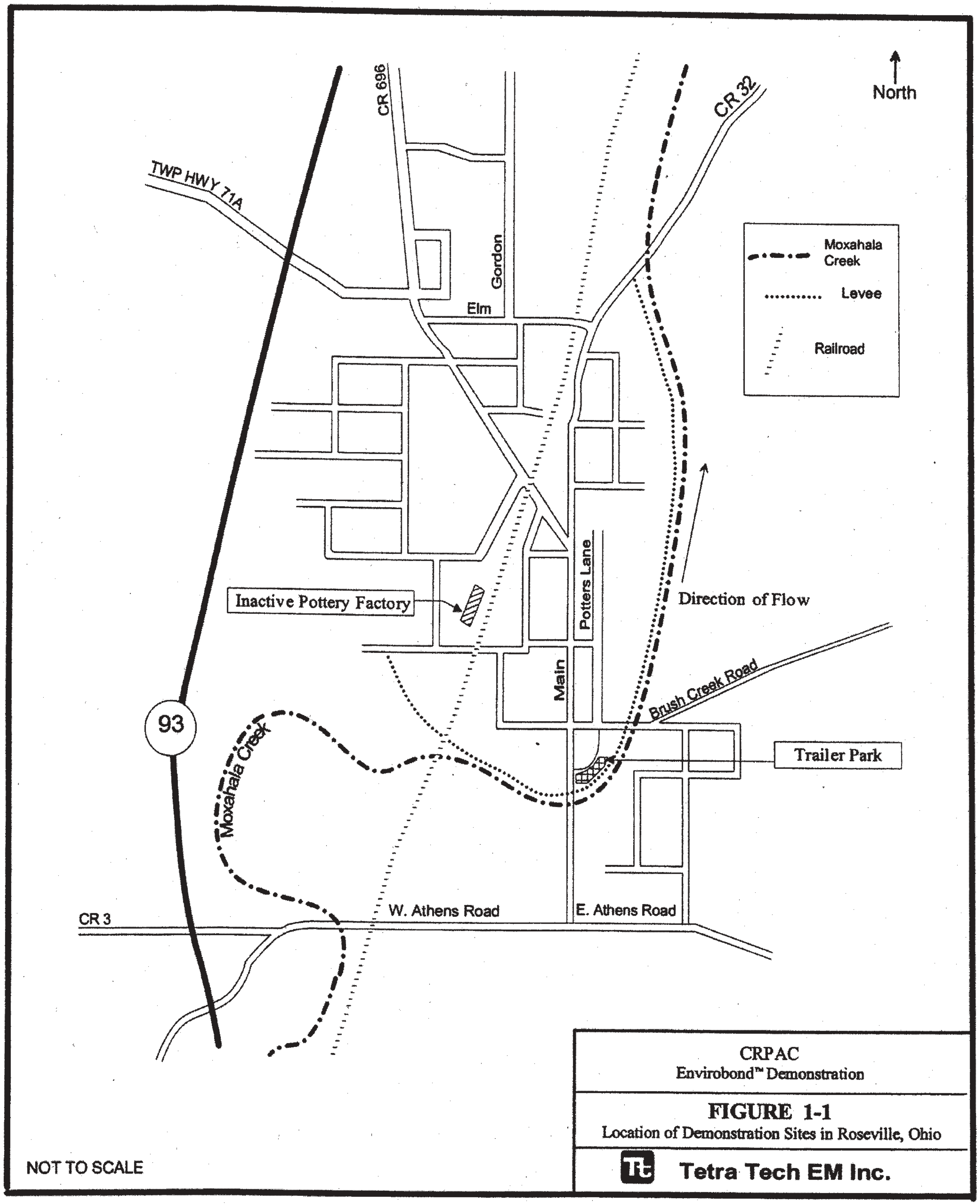

Figure 1-1. Location of demonstration sites in Roseville, Ohio.

applied at the CRPAC. OEPA was considering excavating the soil and stabilizing it with Portland cement; however, the agency also sought to evaluate an innovative technology that could be applied in lieu of soil excavation and that was lower in cost than the cement-based soil stabilization technology. OEPA indicated that children in the CRPAC exhibited higher blood concentrations of lead than children in areas that are not affected by the waste disposal practices of the pottery factories. Therefore, OEPA also was interested in identifying a technology that could reduce the risk of direct exposure to lead in the soil at the CRPAC. To meet OEPA's needs, the SITE program recommended the evaluation of Envirobond™ because it is a technology that can be applied *in situ* with standard construction or farm equipment. EPA refined the objectives of the demonstration project during a meeting with OEPA on March 19, 1998. During and following this meeting, EPA and OEPA established primary and secondary objectives for the SITE demonstration. The objectives were based on EPA's understanding of the technology; information provided by the developers of Envirobond™; the needs identified by OEPA; and the goals of the SITE demonstration program, which include providing potential users of Envirobond™ with technical information to be used in determining whether the technology is applicable to other contaminated sites.

The objectives of the demonstration originally were defined in the EPA-approved QAPP dated November 1998 (Tetra Tech 1998). The two primary objectives are structured to evaluate the ability of the technology to reduce the leachable and bioaccessible concentrations of lead in soils, respectively. The secondary objectives are structured to evaluate the technology's ability to meet other performance goals not considered critical, to document conditions at the site, to document the operating and design parameters of the technology, and to determine the costs of applying the technology.

Primary Objectives

Two primary objectives were developed for the demonstration.

- Primary objective 1 (P1) was to evaluate whether leachable lead in soil can be reduced to concentrations that comply with the alternative UTS for lead in contaminated soil, which are codified at 40 Code of Federal Regulations (CFR) part 268.49 and are included in the land disposal requirements (LDR) set forth under the Resource Conservation and Recovery Act (RCRA)/Hazardous and Solid Waste Amendments (HSWA).

- Primary objective 2 (P2) was to determine whether the portion of total lead in soil that is "bioaccessible," as measured by an experimental method, could be reduced by at least 25 percent. However, it was recognized early on that meeting this goal would be difficult because the SIVM test procedure used in the demonstration involves a highly acidic sample digestion process, which may be revised in the future, because it may be exceeding the acid concentrations that would be expected in a human stomach.

Each of the objectives is described below.

Concentrations of lead in contaminated soils that are the subject of cleanup actions often meet the definition of a hazardous waste under RCRA/HSWA. Sometimes, the goals for such cleanup actions include a requirement that the soil be treated, either *in situ* or *ex situ*, to the point that it is in compliance with the LDRs set forth under RCRA/HSWA. A common reason for including such a treatment goal is to ensure that the lead in treated soil is immobilized sufficiently to make it unlikely that the soil will migrate to groundwater. A treated soil is deemed to be in compliance with the LDRs for lead if the concentration of lead, as measured by a TCLP analysis, is 90 percent lower than the concentration of untreated soil or the treated soil is less than or equal to 7.5 milligrams per liter (mg/L). Objective P1 for this demonstration required that the mean concentration of TCLP lead in the treated soil be 90 percent lower than the concentration in untreated soil or less than or equal to 7.5 mg/L. In addition, the objective required the use of statistical analyses of mean concentrations of TCLP lead, in which the alpha level was set at 0.05.

Bioaccessibility of lead is not normally measured at contaminated sites. The treatment goals for sites at which the soil is contaminated with lead usually are based on the results obtained from lead exposure models that can calculate a maximum total concentration of lead in soil that will not cause blood concentrations of lead in children that exceed the widely accepted threshold level of 10 micrograms per deciliter (Fg/dL). Such models often include a factor that determines the portion of total lead (after ingestion) that is bioavailable. Bioavailability refers to that portion of total soil lead that is absorbed into the bloodstream from the ingestion of the soil (Interstate Technology and Regulatory Cooperation [ITRC] 1997); it is determined through the use of a number of techniques approved by EPA that incorporate the results of in-vivo tests. "Bioaccessibility" of soil lead has been proposed as a term that refers to the results of simpler, in-vitro tests that can be used as indicators of the bioavailability of soil lead. One such test method is the In-Vitro Method for Determination of Lead and Arsenic Bioaccessibility (or simplified in vitro method [SIVM]), which was developed by the Solubility/Bioaccessibility Research Consortium (SBRC) (ITRC 1997). The test simulates digestion of ingested lead in soil, using a combination of chemicals found in the human stomach. Although the EPA Lead Sites Workgroup (LSW) and Technical Review Workgroup (TRW) for lead currently do not endorse an in vitro test for determining soil lead bioavailability (ITRC 1997), such tests, if endorsed in the future, have the potential for use in rapid evaluation of the ability of soil treatment chemicals to reduce the total concentrations of bioavailable lead. The SIVM currently is undergoing validation studies. In previous studies, the test results correlated well with results of analysis by in vivo for soil lead tests based on the Sprague-Dawley rat model and a swine model (ITRC 1997). Primary objective P2 was to evaluate whether Envirobond™ could decrease the bioaccessibility of soil lead (as measured by the SIVM) by 25 percent or more. In addition, the objective required the use of statistical analyses of mean percent lead concentrations, in which the alpha level was set at 0.05.

Secondary (S) Objectives

Secondary objectives were established to collect additional data considered useful, but not critical, to the evaluation of Envirobond™. The secondary objectives of the demonstration were as follows:

- Secondary Objective 1 (S1) - Evaluate the long-term chemical stability of the treated soil.
- Secondary Objective 2 (S2) - Demonstrate that the application of Envirobond™ did not increase the public health risk of exposure to lead.
- Secondary Objective 3 (S3) - Document baseline geophysical and chemical conditions in the soil before the addition of Envirobond™.
- Secondary Objective 4 (S4) - Document operating and design parameters of Envirobond™.

S1 was to determine whether Envirobond™ can enhance the long-term chemical stability of the treated soil. Long-term chemical stability is demonstrated most convincingly through an extended monitoring program. However, the results of such programs may not be available for several years. Therefore, a number of alternative analytical procedures were selected and applied to untreated and treated soils collected from both sites. Those procedures included the multiple extraction procedure (MEP), lead speciation using a scanning electron microscope (SEM), lead speciation with a sequential extraction procedure, oxidation-reduction potential (Eh), pH, cation exchange capacity (CEC), acid neutralization capacity, total lead (as determined by two different methods), leachable lead by the synthetic precipitation leaching procedure (SPLP), total phosphates, and SPLP-leachable phosphates. The evaluation was accomplished by comparing the results of the analytical procedures on soil samples collected from both sites before and after application of Envirobond™. Section 2.3 of this ITER provides additional details about each analytical procedure and the criteria applied in interpreting the results obtained.

S2 was to determine whether the dust generated during the application of Envirobond™ may increase risks to the public health posed by inhalation of lead during full-scale implementation. The evaluation was accomplished by analyzing residuals from air samples that were drawn through filters during those demonstration activities that could create dust and comparing the analytical results with the National Ambient Air Quality Standard (NAAQS) for lead.

S3 was to evaluate baseline geophysical and chemical properties of the soil at both sites. The objective was accomplished by classifying soil samples from both sites and analyzing them for volatile organic compounds (VOC), semivolatile organic compounds (SVOC), oil and grease, and humic and fulvic acids.

S4 was to estimate the costs associated with the use of Envirobond™. The cost estimates were based on observations made and data obtained during and after the demonstration, as well as data provided by RMRS.

1.3.4 Demonstration Activities

Personnel of the SITE program evaluated the objectives of the demonstration by collecting and analyzing surficial soil samples before and after Envirobond™ was applied. Soil samples collected from the inactive pottery factory and the trailer park were used in determining success in accomplishing objective P1. In the case of P2, only soil samples collected from the trailer park were used. In general, five types of data were obtained: (1) TCLP lead concentrations in untreated and treated soils; (2) bioaccessibility levels of lead in untreated and treated soils; (3) various levels of parameters for evaluating the long-term chemical stability of untreated and treated soils; (4) concentrations of lead in air during sampling and treatment activities; and (5) levels of baseline geophysical and chemical parameters in untreated soils. The sampling program was designed specifically to support the demonstration objectives presented in Section 1.3.3. Section 2.0 of this ITER discusses the results of the evaluation.

1.3.5 Long-term Monitoring

A long-term monitoring program was established; under that program, additional samples of soil are to be collected quarterly and analyzed for soil lead bioaccessibility, TCLP lead, concentrations of SPLP lead, and concentrations of lead in groundwater. Water samples will be collected quarterly from lysimeters installed in experimental units at both sites and analyzed for lead. Samples of grass will be collected from experimental units at the trailer park. Information obtained through the long-term monitoring effort will be presented in reports to be issued periodically as the long-term monitoring program proceeds.

1.4 Key Contacts

Additional information about the SITE program, Envirobond™, RMRS, OEPA, and the analytical laboratories is available from the following sources:

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